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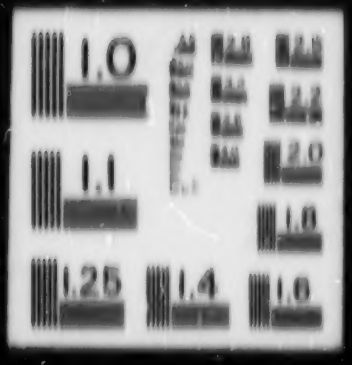

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National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Oreg

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REPORT

ON

EAGLE MOUNTAIN LAKE

TARRANT AND WISE COUNTIES

TEXAS

EPA REGION VI

WORKING PAPER NO. 643

WITH THE COOPERATION OF THE

TEXAS WATER QUALITY BOARD

AND THE

TEXAS NATIONAL GUARD

FEBRUARY, 1977

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Texas Water Quality Board for professional involvement, to the Texas National Guard for conducting the tributary sampling phase of the Survey, and to those Texas wastewater treatment plant operators who voluntarily provided effluent samples.

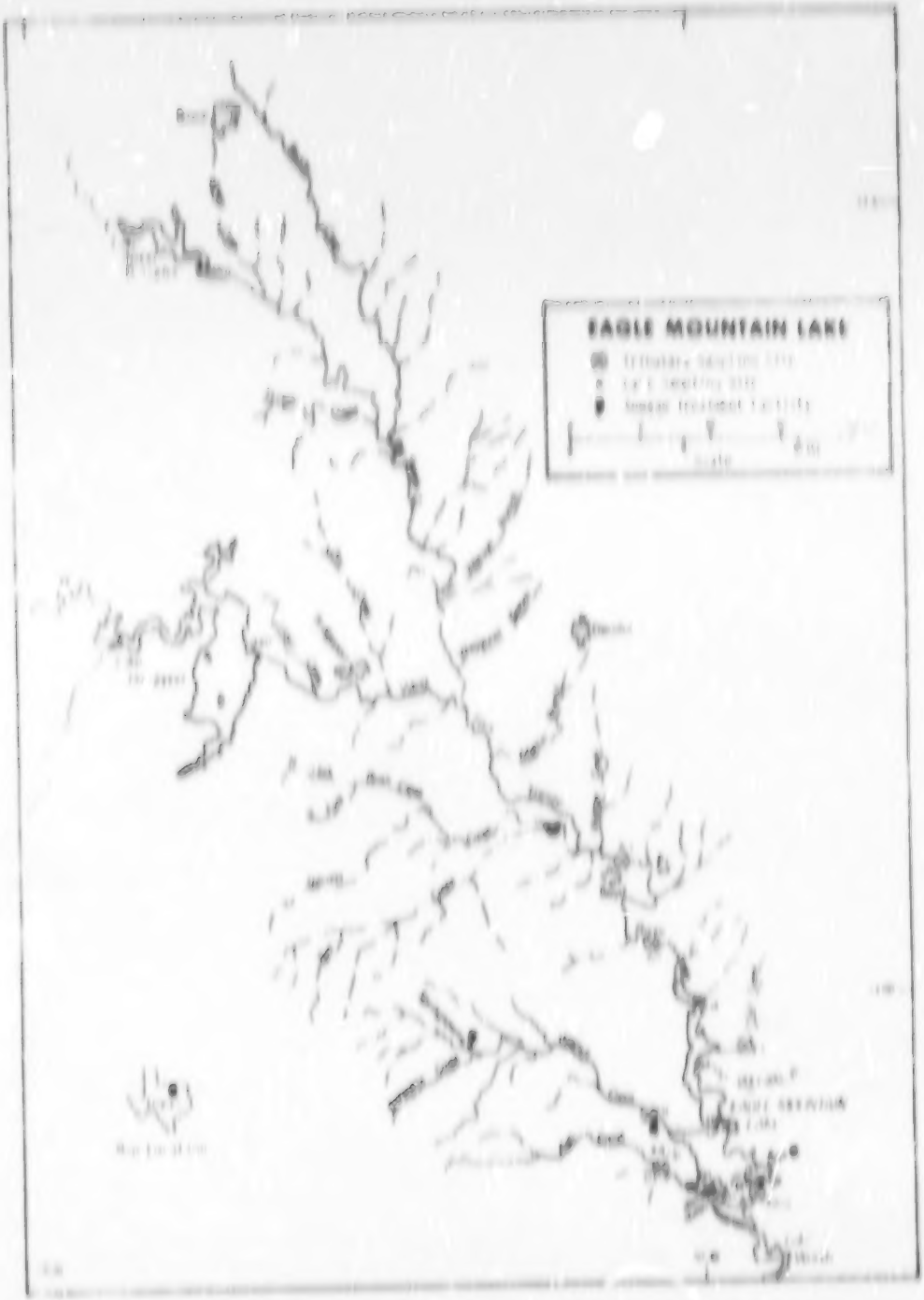
Hugh C. Yantis, Jr., Executive Director of the Texas Water Quality Board, and John B. Latchford, Jr., Director, and the staff of the Field Operations Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Thomas Bishop, the Adjutant General of Texas, and Project Officer Colonel William L. Seals, who directed the volunteer efforts of the Texas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY
STUDY RESERVOIRS
State of Texas

NAME	COUNTY
Amistad	Val Verde
Bastrop	Bastrop
Belton	Bell, Coryell
Braunig	Bexar
Brownwood	Brown
Buchanan	Burnet, Llano
Caddo	Harrison, Marion, TX; Caddo Parish, LA
Calaveras	Bexar
Canyon	Comal
Colorado City	Mitchell
Corpus Christi	Jim Wells, Live Oak, San Patricio
Diversion	Archer, Baylor
Eagle Mountain	Tarrant, Wise
Fort Phantom Hill	Jones
Houston	Harris
Kemp	Baylor
Lake O'The Pines	Camp, Marion, Morris, Upshur
Lavon	Collin
Lewisville (Garza-Little Elm)	Denton
Livingston	Polk, San Jacinto, Trinity, Walker

Lyndon B. Johnson	Burnet, Llano
Medina	Bandera, Medina
Meredith	Hutchinson, Moore, Potter
O. C. Fisher (San Angelo)	Tom Green
Palestine	Anderson, Cherokee, Henderson, Smith
Possum Kingdom	Palo Pinto, Stephens, Young
Sam Rayburn	Angelina, Jasper Nacogdoches, Sabine, San Augustine
Somerville	Burleson, Lee, Washington
E. V. Spence	Coke
Stamford	Haskell
Stillhouse Hollow	Bell
Tawakoni	Hunt, Rains, Van Zandt
Texoma	Cooke, Grayson TX; Bryan, Johnston, Love, Marshall, OK
Travis	Burnet, Travis
Trinidad	Henderson
Twin Buttes	Tom Green
White River	Crosby
Whitney	Bosque, Hill
Wright Patman (Texarkana)	Bowie, Cass


EAGLE MOUNTAIN LAKE

EAGLE MOUNTAIN LAKE

STORET NO. 4813

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Eagle Mountain Lake is meso-eutrophic; i.e., moderately well supplied with nutrients and productive. Whether nutrient enrichment is beneficial or deleterious depends on the actual or potential effect on the uses of the lake. In this regard, no nuisance conditions are known to personnel of the Texas Water Quality Board and there is little or no impairment of the designated beneficial uses of this lake.

Eagle Mountain Lake ranked third in overall trophic quality when the 39 Texas reservoirs sampled in 1974 were compared using a combination of six lake parameters*. Eleven of the water bodies had less median total phosphorus, eight had less and two had the same median dissolved orthophosphorus, two had less and three had the same median inorganic nitrogen, eight had less mean chlorophyll a, and 25 had greater mean Secchi disc transparency. Some depression of dissolved oxygen with depth occurred at sampling station 2 in May.

Survey limnologists noted substantial shoreline beds of macrophytes in the upper end of the lake in March. Turbidity due to suspended silt was observed throughout the lake in August.

B. Rate-Limiting Nutrient:

Due to significant changes in nutrient levels in the samples, the algal assay results are not representative of conditions in the lake at the times the samples were collected.

* See Appendix A.

the lake data indicate that primary productivity was predominately nitrogen-limited.

C. Nutrient Controllability:

1. Point sources--It is calculated that point sources contributed only about 3% of the total phosphorus load to Eagle Mountain Lake during the sampling year. The Springtown and Azle municipal wastewater treatment plants were the major contributors.

During the sampling year, the lake received a total phosphorus loading over three times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 14). However, because of the large non-point contribution, it does not seem likely that point-source phosphorus control would result in a significant improvement in the trophic condition of the lake.

2. Non-point sources--It is calculated that non-point sources contributed about 97% of the total phosphorus load to the lake during the sampling year. The West Fork of the Trinity River contributed nearly 83% of the total load, the minor tributaries and immediate drainage contributed about 7%, Walnut Creek 3.5%, and Ash Creek contributed about 2%.

The phosphorus export rates of the Eagle Mountain Lake tributaries (see page 13) were somewhat high as compared to Texas streams sampled elsewhere; e.g., the mean of the export rates of three tributaries of nearby Possum Kingdom Reservoir[4] was 5 kg/km^2/yr (range of 3 to 8 kg/km^2/yr).

[4] Working Paper No. 855.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 36.42 kilometers²,

2. Mean depth: 6.4 meters,

3. Maximum depth: 15.8 meters,

4. Volume: 233,775 x 10^3 m^3,

5. Mean hydraulic retention time: 363 days (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
W. Fk. Trinity River (A-2)	4,581.7	6.500
Ash Creek	50.3	0.212
Walnut Creek	187.0	0.618
Minor tributaries & immediate drainage -	230.9	0.770
Totals	5,065.9	8.100

2. Outlets -

West spillway (A-1)	-	1.357
Main dam conduits (B-1)	5,102.3	6.090
Totals	5,102.3**	7.447**

C. Precipitation***:

1. Year of sampling: 99.7 centimeters.

2. Mean annual: 82.2 centimeters.

† Table of metric conversions--Appendix B.
†† Gamble, 1974.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake; lesser outflow due to evaporation.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Eagle Mountain Lake was sampled four times in 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two or more depths at four stations on the lake (see map, page vi). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 5.3 meters at station 1, 12.8 meters at station 2, 8.5 meters at station 3, and 1.8 meters at station 4.

The sampling results are presented in full in Appendix D and are summarized in the following table.

[illegible] OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR [illegible]
[illegible]

PARAMETER	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TEMP (C)	22.2 - 28.3	25.6	25.6	25.0 - 27.1	26.1	26.2	26.2 - 26.6	26.4	26.4
DISS OXY (MG/L)	6.8 - 10.2	8.2	8.3	4.5 - 5.6	6.7	7.2	5.2 - 7.2	6.5	6.7
CONDTVY (MICROMO)	380. - 480.	347.	384.	420. - 520.	450.	467.	370. - 430.	400.	404.
PH (STAND UNITS)	7.9 - 8.3	8.1	8.2	7.7 - 8.3	8.2	8.3	7.9 - 8.7	8.4	8.3
TOT ALK (MG/L)	135. - 178.	142.	137.	134. - 147.	138.	139.	124. - 137.	130.	133.
TOT P (MG/L)	0.054 - 0.092	0.071	0.072	0.062 - 0.094	0.078	0.073	0.071 - 0.112	0.094	0.075
DISS P (MG/L)	0.033 - 0.038	0.037	0.037	0.033 - 0.054	0.039	0.035	0.036 - 0.058	0.051	0.036
ORTHO P (MG/L)	0.029 - 0.043	0.034	0.033	0.038 - 0.058	0.049	0.050	0.027 - 0.035	0.033	0.033
AMMONIA (MG/L)	0.028 - 0.040	0.035	0.033	0.038 - 0.066	0.040	0.040	0.050 - 0.070	0.042	0.070
KJEL N (MG/L)	0.256 - 0.788	0.436	0.468	0.338 - 1.053	0.584	0.588	0.388 - 0.488	0.471	0.388
INORG N (MG/L)	0.042 - 0.088	0.054	0.048	0.060 - 0.178	0.084	0.096	0.078 - 0.488	0.302	0.178
TOTAL N (MG/L)	0.298 - 0.735	0.490	0.435	0.338 - 1.438	0.653	0.556	0.488 - 0.528	0.387	0.258
CHLOPHYL A (MG/L)	2.0 - 5.6	3.9	3.5	1.0 - 13.4	5.2	2.9	5.5 - 12.9	8.6	4.3
[illegible] (METERS)	0.4 - 0.9	0.7	0.7	0.2 - 1.0	0.5	0.6	0.3 - 1.2	0.6	0.9

[illegible]

[illegible]

PARAMETER	[illegible]	[illegible]	[illegible]
[illegible]	25.0 - 25.1	25.2	25.1
[illegible]	7.4 - 8.6	7.4	7.6
[illegible]	35% - 39%	34%	35%
[illegible]	4.8 - 8.2	8.1	8.1
[illegible]	117. - 134.	124.	122.
[illegible]	0.827 - 0.837	0.834	0.838
[illegible]	0.815 - 0.824	0.821	0.817
[illegible]	0.828 - 0.838	0.831	0.838
[illegible]	0.828 - 0.838	0.835	0.835
[illegible]	0.358 - 0.368	0.361	0.358
[illegible]	0.844 - 0.856	0.854	0.845
[illegible]	0.342 - 0.348	0.345	0.345
[illegible]	1.6 - 8.7	8.7	8.3
[illegible]	8.3 - 8.6	8.7	8.7

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/07/74	1. Stephanodiscus sp.	606
	2. Chroomonas sp.	572
	3. Flagellates	337
	4. Ankistrodesmus sp.	269
	5. Dactylococcopsis sp.	236
	Other genera	1,044
	Total	3,064
05/16/74	1. Nitzschia sp.	928
	2. Chlorophytan filaments	698
	3. Melosira sp.	210
	4. Merismopedia sp.	210
	5. Flagellates	180
	Other genera	898
	Total	3,324
08/13/74	1. Nitzschia sp.	207
	2. Trachelomonas sp.	146
	3. Melosira sp.	118
	4. Anabaenopsis sp.	89
	5. Lyngbya sp.	89
	Other genera	325
	Total	976
10/30/74	1. Melosira sp.	306
	2. Chroomonas sp.	275
	3. Cyclotella sp.	275
	4. Nitzschia sp.	244
	5. Merismopedia sp.	183
	Other genera	886
	Total	2,169

B. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
03/07/74	1	5.6
	2	2.6
	3	2.6
	4	4.5
05/16/74	1	1.4
	2	1.9
	3	3.9
	4	13.8
08/13/74	1	12.9
	2	9.4
	3	5.5
	4	7.6
10/30/74	1	2.7
	2	1.6
	3	5.9
	4	6.7

C. Limiting Nutrient Study:

Significant changes in nutrient levels occurred in the assay samples during shipment from the field to the laboratory, and the results are not indicative of conditions in the lake at the times the samples were taken (03/07/74 and 10/30/74).

The lake data indicate that primary productivity was predominately nitrogen-limited each sampling time (the mean inorganic nitrogen to orthophosphorus ratios were less than 14 to 1). Phosphorus limitation occurred only at sampling station 1 in May and

at station 3 in May and August (the N to P ratios were 17 to 1, 15 to 1, and 20 to 1, respectively).

Nitrogen limitation, as indicated by in-lake nitrogen to phosphorus ratios, does not necessarily mean that the trophic condition of the lake can be improved by controlling nitrogen inputs. In many cases, the apparent condition of nitrogen-limitation results from excessive phosphorus input from point sources and is often accompanied by a corresponding increase in primary production. In such cases, the reversal of the enriched condition depends upon phosphorus control, not nitrogen control.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Texas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the high runoff month of April when two samples were collected at most of the sites. Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Texas District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads for outlet station B-1, which was sampled only four times, were calculated using the mean annual concentrations at outlet station A-1 and the mean annual flow at station B-1. Tributary loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in Ash Creek at station C-1 and the mean annual ZZ flow.

The operators of the Azle, Springtown, and Fort Worth Boat Club wastewater treatment plants provided monthly effluent samples and corresponding flow data.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Springtown	1,194	stab. pond	690.4	Walnut Creek
Azle	2,500	extd. ditch	134.4	Walnut Creek
Fort Worth Boat Club	300	act. sludge	21.6	Eagle Mountain Lake

2. Known industrial - None

*Treatment plant questionnaires.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr.	% of total
a. Tributaries (non-point load) -		
W. Fk. Trinity River (A-R)	45,505	82.6
Ash Creek	1,105	2.0
Walnut Creek	1,960	3.6
b. Minor tributaries & immediate drainage (non-point load) -	4,005	7.3
c. Known municipal STP's -		
Springtown	1,150	2.1
Azle	530	1.0
Fort Worth Boat Club	75	0.1
d. Septic tanks* -	165	0.3
e. Known industrial - None	-	-
f. Direct precipitation** -	635	1.1
Total	55,120	100.0

A. Outputs -

Lake outlet -	Main dam conduits	7,680
	West spillway	1,710
	Total	9,390

3. Net annual P accumulation - 45,730 kg.

* Estimate based on 590 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
W. Fk. Trinity River (A-2)	337,405	76.0
Ash Creek	6,365	1.4
Walnut Creek	27,635	6.2
b. Minor tributaries & immediate drainage (non-point load) -	23,115	5.2
c. Known municipal STP's -		
Springtown	2,415	0.6
Azle	1,365	0.3
Fort Worth Boat Club	100	<0.1
d. Septic tanks* -	6,290	1.4
e. Known industrial - None	-	-
f. Direct precipitation** -	39,320	8.9
Total	444,030	100.0

2. Outputs -

Lake outlets -	Main dam conduits	193,205
	West spillway	43,050
	Total	236,255

3. Net annual N accumulation - 207,775 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
W. Fk. Trinity River (A-2)	10	74
Ash Creek	19	109
Walnut Creek	10	148

* Estimate based on 590 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Mean Nutrient Concentrations in Engaged Stream:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Indian Creek	0.042	1.071

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	1.51	1.26	12.2	5.7

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Eagle Mountain Lake:

"Dangerous" (eutrophic loading)	0.50
"Permissible" (oligotrophic loading)	0.25

V. LITERATURE REVIEWED

Gambol, Robert D., 1974. Fishery management recommendations, Fed. Aid Proj. F-4-R-21, TX Parks & Wildlife Dept., Austin.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research, Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE LISTING TO BE USED IN CHAPTER

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible]
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[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE OF THE [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] [illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] [illegible] [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] [illegible] [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] [illegible] [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] [illegible] [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	E [illegible] SPRING [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

LAKE CODE	LAKE NAME	[illegible] TOTAL #	[illegible] INCH/ %	[illegible] MEAN SIZE	[illegible] CM/HA	[illegible] #/1	[illegible] /ESU [illegible] #	[illegible] NO
[illegible]	[illegible] LAKE	65 (36)	5 (2)	108 (38)	108 (38)	29 (10)	13 (5)	46
[illegible]	[illegible] LAKE	76 (30)	74 (29)	62 (31)	47 (18)	17 (3)	42 (34)	343
[illegible]	[illegible] RESERVOIR	62 (35)	26 (10)	47 (17)	63 (26)	17 (0)	64 (35)	38
[illegible]	[illegible] LAKE	5 (2)	42 (16)	58 (19)	0 (1)	48 (17)	5 (2)	179
[illegible]	[illegible] LAKE	66 (25)	78 (29)	29 (11)	67 (33)	58 (23)	64 (35)	39
[illegible]	LAKE [illegible]	47 (18)	21 (7)	74 (28)	63 (24)	17 (0)	34 (14)	29
[illegible]	CABIN LAKE	26 (10)	91 (33)	42 (16)	32 (12)	76 (29)	38 (12)	29
[illegible]	DALAS-H-S LAKE	45 (17)	108 (38)	47 (19)	11 (4)	67 (25)	92 (34)	36
[illegible]	DAYTON RESERVOIR	49 (27)	0 (3)	95 (36)	47 (37)	46 (17)	67 (37)	44
[illegible]	LAKE COLBURED CITY	39 (14)	76 (28)	26 (10)	42 (16)	88 (32)	39 (14)	21
[illegible]	CORPUS CHRISTI LAKE	8 (3)	47 (18)	18 (7)	13 (5)	61 (23)	8 (3)	19
[illegible]	EDWARDS LAKE	59 (26)	63 (31)	32 (12)	29 (11)	47 (37)	63 (21)	37
[illegible]	EAGLE MOUNTAIN LAKE	72 (27)	91 (33)	34 (13)	76 (38)	74 (36)	75 (28)	43
[illegible]	FT PHANTOM HILL LAKE	24 (9)	66 (25)	21 (8)	74 (28)	95 (36)	16 (6)	24
[illegible]	GARZA LITTLE ELM RESERVO	34 (13)	13 (5)	16 (6)	36 (13)	55 (21)	21 (7)	17
[illegible]	HOUP LAKE	78 (28)	60 (23)	55 (21)	55 (21)	94 (32)	97 (36)	42
[illegible]	HOUSTON LITE	16 (6)	16 (6)	8 (6)	24 (9)	72 (27)	11 (4)	13
[illegible]	LAKE OF THE PINES	54 (20)	78 (29)	66 (25)	39 (15)	17 (0)	46 (17)	24
[illegible]	LAVON RESERVOIR	21 (8)	29 (11)	3 (1)	84 (32)	100 (38)	21 (7)	25
[illegible]	LEWISVILLE LAKE	3 (1)	3 (1)	39 (15)	26 (10)	17 (0)	3 (1)	9
[illegible]	LYNDA B JOHNSON LAKE	38 (14)	11 (4)	53 (20)	46 (25)	38 (14)	36 (10)	23
[illegible]	MEDINA LAKE	98 (37)	0 (0)	69 (34)	37 (14)	17 (0)	100 (38)	34
[illegible]	LAKE MERRITT	62 (30)	41 (19)	71 (27)	95 (36)	35 (14)	63 (21)	44
[illegible]	PALESTINE LAKE	54 (20)	32 (12)	63 (24)	53 (20)	49 (17)	51 (19)	36
[illegible]	[illegible] RESERVOIR	74 (28)	41 (15)	84 (32)	58 (22)	17 (2)	63 (21)	39
[illegible]	SAN ANGELO RESERVOIR	13 (5)	45 (17)	0 (3)	8 (0)	88 (33)	42 (17)	28
[illegible]	SAN ANTONIO RESERVOIR	59 (27)	39 (15)	68 (26)	76 (29)	17 (0)	63 (21)	32
[illegible]	E O SPENCE RESERVOIR	58 (19)	63 (31)	45 (17)	58 (19)	17 (0)	76 (28)	32

PERCENT OF LAKES WITH HIGHER VALUES; NUMBER OF LAKES WITH HIGHER VALUES

LAKE CODE	LAKE NAME	TOTAL P	DISSOLVED P	CHLOROPHYLL	SECCHI DEPTH	COLOR	ALKALINITY	[H+]
4429	SUNDRYVILLE LAKE	29 (110)	95 (237)	24 (91)	3 (11)	67 (251)	89 (333)	49*
4430	STAMFORD LAKE	19 (71)	47 (177)	5 (21)	18 (71)	82 (311)	39 (146)	259
4431	STILLWATER MILLION MEDIAN	89 (333)	37 (140)	87 (331)	92 (350)	17 (61)	51 (190)	372
4432	THAMPSON LAKE	32 (121)	78 (296)	37 (140)	21 (80)	63 (240)	38 (144)	453
4433	TEWKSBURY LAKE	11 (40)	51 (190)	13 (51)	16 (61)	72 (275)	11 (54)	176
4434	TEXOMA LAKE	36 (140)	34 (129)	61 (229)	45 (171)	17 (61)	21 (71)	217
4435	THAMES LAKE	84 (319)	21 (71)	82 (311)	82 (311)	17 (61)	84 (321)	384
4436	THOMSONS	0 (0)	61 (229)	11 (40)	5 (21)	92 (350)	0 (0)	169
4437	TWIN BUTTES RESERVOIR	59 (225)	21 (71)	53 (201)	61 (229)	49 (171)	63 (231)	311
4438	WHITE HORSE RESERVOIR	84 (319)	61 (229)	76 (290)	69 (260)	17 (61)	63 (231)	345
4439	WHITNEY LAKE	63 (240)	51 (190)	76 (301)	71 (271)	17 (61)	76 (290)	257

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

[illegible]

LAKE [illegible] #13 [illegible]

TOTAL DRAINAGE AREA OF LAKE(SQ MI) [illegible]

THIS/THAT	SUB-DRAINAGE AREA(SQ MI)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
[illegible]	5102.3	3.49	2.42	9.29	7.11	34.17	7.87	3.61	9.14	9.34	4.62	4.14	3.48	9.14
[illegible]	4581.7	3.17	2.35	3.91	6.62	18.76	6.34	5.92	7.39	8.48	8.34	4.45	2.74	8.51
[illegible]	5102.3	8.848	6.591	8.845	2.413	9.371	4.821	8.088	8.094	1.745	1.313	1.841	8.457	1.357
[illegible]	54.3	8.167	8.221	8.114	8.491	8.595	8.167	8.886	8.825	8.173	8.173	8.173	8.196	8.212
[illegible]	167.4	8.568	8.621	8.534	1.111	1.727	8.621	8.253	8.098	8.453	8.481	8.451	8.411	8.619
[illegible]	774.5	8.62	8.68	8.19	1.34	2.12	8.79	8.48	8.24	8.45	8.45	8.39	8.37	8.77

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 5102.3 TOTAL FLOW IN = [illegible]

SUM OF SUB-DRAINAGE AREAS = 5661.5 TOTAL FLOW OUT = [illegible]

[illegible] MONTHLY FLOWS AND ANNUAL FLOW(CMS)

THIS/THAT	[illegible]	[illegible]	[illegible] FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
[illegible]	0	74	2,747	7	1,419				
	10	74	3,498	7	2,8				
	11	74	3,823	12	8,889				
	12	74	3,115	13	1,889				
	1	75	1,398	25	8,819				
	2	75	2,917	17	8,8				
	3	75	6,447	25	4,119				
	4	75	3,588	15	8,8	30	8,8		
	5	75	12,573	29	7,489				
	6	75	13,461						
	7	75	8,637	29	9,119				
	8	75	4,361	10	8,8				
[illegible]	9	74	3,443	7	8,651				
	10	74	18,776	7	8,395				
	11	74	15,425	11	21,442				
	12	74	1,388	25	1,111				
	1	75	1,184	25	8,419				
	2	75	8,654	17	1,382				
	3	75	4,398	29	1,412				
	4	75	5,888	15	3,443	30	1,429		
	5	75	8,758	29	2,528				
	6	75	14,881	21	1,511				
	7	75	13,134	29	68,244				
	8	75	3,872	10	8,673				

APPENDIX D

PHYSICAL and CHEMICAL DATA

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	CENT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	15	55	[illegible]	17.4		29	[illegible]	4.22	140	[illegible]	[illegible]	[illegible]
	15	55	[illegible]	17.6	6.7		[illegible]	4.21	139	[illegible]	[illegible]	[illegible]
	15	55	[illegible]	16.3	6.6		[illegible]	4.21	141	[illegible]	[illegible]	[illegible]
	15	55	[illegible]	15.3	6.4		[illegible]	4.15	142	[illegible]	[illegible]	[illegible]
[illegible]	15	10	[illegible]	27.1		39	[illegible]	4.31	136	[illegible]	[illegible]	[illegible]
	15	10	[illegible]	27.1	7.6		[illegible]	4.32	135	[illegible]	[illegible]	[illegible]
	15	10	[illegible]	25.6	7.6		[illegible]	4.30	136	[illegible]	[illegible]	[illegible]
	15	10	[illegible]	25.6	7.2		[illegible]	4.25	137	[illegible]	[illegible]	[illegible]
[illegible]	14	15	[illegible]	28.6	7.8	44	[illegible]	4.06	133	[illegible]	[illegible]	[illegible]
	14	15	[illegible]	27.3			[illegible]	4.02	134	[illegible]	[illegible]	[illegible]
	14	15	[illegible]	27.4	7.8		[illegible]	4.02	129	[illegible]	[illegible]	[illegible]
	14	15	[illegible]	26.2	6.5		[illegible]	4.04	132	[illegible]	[illegible]	[illegible]
[illegible]	15	55	[illegible]	28.7	6.6	38	[illegible]	4.21	128	[illegible]	[illegible]	[illegible]
	15	55	[illegible]	28.7	6.4		[illegible]	4.21	129	[illegible]	[illegible]	[illegible]
	15	55	[illegible]	28.7	6.8		[illegible]	4.17	125	[illegible]	[illegible]	[illegible]
	15	55	[illegible]	28.6	7.8		[illegible]	4.13	117	[illegible]	[illegible]	[illegible]

DATE	[illegible]	DEPTH	[illegible]	[illegible]	[illegible]
[illegible]	OF		[illegible]	[illegible]	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]
[illegible]	15	55	[illegible]	2.6	
	15	55	[illegible]		
	15	55	[illegible]		
	15	55	[illegible]		
[illegible]	15	10	[illegible]	1.9	
	15	10	[illegible]		
	15	10	[illegible]		1.0
	15	10	[illegible]		
	15	10	[illegible]		
[illegible]	14	15	[illegible]	5.5	
	14	15	[illegible]		
	14	15	[illegible]		
	14	15	[illegible]		
[illegible]	15	55	[illegible]	5.9	
	15	55	[illegible]		
	15	55	[illegible]		
	15	55	[illegible]		

* [illegible]
[illegible]

APPENDIX I

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	MG/L	MG/L	MG/L	MG/L P	MG/L P
[illegible]	11	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	17	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	14	25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	15	21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]
[illegible]
[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
74/04/27	09	48	1.894	1.588	0.838	1.098	0.147
74/06/07	14	09	1.844	0.488	0.827	0.848	0.138
74/11/11	13	05	1.168	1.588	0.845	1.185	0.331
74/12/23	14	15	1.844	1.788	0.824	1.036	3.648
75/01/24	16	18	1.887	1.467	0.828	1.048	0.538
75/02/17	09	24	0.386	1.456	0.854	0.858	0.161
75/03/26	05	28	0.196	3.873	0.855	0.865	0.481
75/04/15	13	36	0.240	1.888	0.858	0.855	0.186
75/04/28	16	79	0.338	1.892	0.145	0.898	0.371
75/05/26	13	48	0.298	1.758	0.185	0.888	0.156
75/06/21	18	75	0.175	0.988	0.822	0.835	0.108
75/07/26	15	35	0.838	0.458	0.838	0.118	0.248
75/08/28	15	84	0.855	0.758	0.838	0.825	0.118

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] METEOROLOGICAL DATA, [illegible]

[illegible]
32 57 [illegible] (NAT 29 [illegible]
[illegible]
[illegible] T.O. MUNICIPAL
TAKEOFF MTS LAMPE
2.7 MI SE OF CITY EAGLE MTS (NOT SHOWN) [illegible]
[illegible] [illegible]
[illegible] FEET [illegible] CLASS [illegible]

DATE, FROM TO	TIME OF DAY	CEILING FEET	VISIBILITY STATUTE MILES	TOTAL SKY COVER TENTHS	WIND SPEED KNOTS	WIND DIRECTION TENS OF DEGREES
[illegible]	13 48		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13 52		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	17 38		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	11 28		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	04 35		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13 05		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	06 04		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13 18		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	06 07		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	05 38		[illegible]	[illegible]	[illegible]	[illegible]

* VALUE HIGHER TO [illegible]
LESS THAN INDICATED

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	MG/L	MG/L	MG/L	MG/L P	MG/L P	[illegible]	[illegible]
75/10/15	10	10	25.100	5.000	3.465	11.400	14.000	0.235	0.035
75/11/06	10	10	25.400	5.000	3.240	6.750	9.900	0.035	0.010
75/12/13	10	17	24.200	6.100	1.200	10.400	11.600	0.040	0.035
75/13/11	10	10	24.000	1.300	0.004	7.000	7.000	0.035	0.035
75/14/22	14	17	24.000	2.000	0.700	5.170	6.200	0.030	0.035
75/15/22	15	14	33.000	3.400	0.356	12.100	12.400	0.070	0.010
75/16/25	15	10	24.000	0.100	0.100	1.400	11.000	0.035	0.030
75/19/11	13	30	24.700	4.700	0.310	9.400	9.600	0.035	0.035
75/11/05	14	10	25.000	5.200	0.170	10.500	14.000	0.035	0.035
75/11/10	11	15	23.000	3.500	0.200	12.400	14.000	0.035	0.035
75/12/27	14	10						0.035	0.030

[illegible]

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

DATE FROM TO	TIME OF DAY	DEPTH FEET	[illegible] MG/L	[illegible] MG/L	[illegible] MG/L	[illegible] MG/L	[illegible] MG/L	[illegible]	[illegible]
7/29/78	06	00							
CP(T)-			11.000	2.700	1.140	1.700	1.100	0.010	0.004
7/29/78	18	00							
7/11/78	06	00							
CP(T)-			1.100	1.000K	0.050K	1.100	0.000	0.005	0.007
7/11/78	24	00							
7/12/78	06	00							
CP(T)-			14.000	1.000K	0.050K	1.100	0.000	0.012	0.008
7/12/78	17	30							
7/13/78	06	00							
CP(T)-			4.200	11.000	0.050K	11.200	12.000	0.004	0.005
7/13/78	20	00							
7/14/78	07	00							
CP(T)-			4.100	0.500K	0.100	5.000	0.010	0.0005	0.001
7/14/78	26	00							
7/14/78	01	00							
CP(T)-			0.200	14.000	1.000	2.200	0.100	0.007	0.005
7/15/78	20	00							

* VALUE KNOWN TO BE
LESS THAN INDICATED

[illegible]